Hydrocarbon Charge Modelling *geofacts*

Nova Scotia Department of Natural Resources
Mineral Resources Branch
Information Circular ME 28, 1992

Table of Contents

- Introduction
- What is a sedimentary basin?
- How do oil and gas form?
- Do the oil and gas come from these source rocks?
- Where do the oil and gas end up?
- Why is hydrocarbon charge modelling important for Canadians?
- Information

Back to Top

Introduction

It is becoming increasingly difficult to find new reserves of oil and gas. Finding them was never straightforward, and the obvious discoveries have already been made. Now, they come after a painstaking and expensive process of exploration and investigation.

In the face of this challenge, petroleum geologists are developing new techniques to make the process more efficient and productive. As part of its contribution to the effort, the Geological Survey of Canada (GSC) has began a new research program to investigate how oil and gas form, migrate through rocks and become trapped in reservoirs suitable for tapping. The program is called Hydrocarbon Charge Modelling.

In this context, "charge" is used to mean "fill", as when guests at a banquet are invited to charge their glasses and drink a toast. And "modelling" refers to the development of computer models - based on research results - to allow petroleum geologists to examine the conditions that have combined to determine the distribution of oil and gas.

Scientists know in a generalized way the processes involved in charging reservoirs with oil and gas. What is missing, is the quantification of the relative importance of these processes. The Hydrocarbon Charge Modelling project will involve a number of scientists from a range of disciplines - geology, geophysics, chemistry, physics and mathematics. The investigation will focus on two east coast sedimentary basins, off Nova Scotia and Newfoundland respectively. Researchers will study these basins in detail in order to understand the physical, chemical and geological processes that are needed for the formation of oil and gas in sufficient quantity to be tapped commercially. This understanding can then be used as a quantitative platform for amongst other things, predicting the potential occurrence of other

oil and gas fields.

Back to Top

What is a sedimentary basin?

Over the many millions of years of geological time, rivers have been eroding the land, carrying the sediment particles down to the sea. As much as 15 kilometres of sediment - mainly sand and mud - has accumulated off the Nova Scotian and Newfoundland coasts over the past 200 million years. The weight of all these layers of sediment, together with processes occurring deep in the Earth's crust, causes subsidence leading to the formation of what are called sedimentary basins. As the basins continue to fill with sediment, the subsidence progresses.

The history of the subsidence and the thermal conditions of the basins are two basic factors contributing to the formation of oil and gas. The study of this history, therefore, is an important component of the project.

Back to Top

How do oil and gas form?

Organic material - the remains of plants flushed along by the rivers and of microscopic plants and animals that lived in the ocean - is sometimes preserved in the basins, along with the sediment. Over time, this organic material is buried and subjected to heat and pressure which transform it into oil and gas. Although not a universal rule, the organic material derived from marine animals usually turns into oil, whereas the material from land plants usually turns into gas.

Petroleum geologists try to identify source rocks containing high amounts of organic material, because their presence is a good indicator of the potential for oil and gas in the region. The shales of the Verrill Canyon Formation are considered the most likely source rocks off Nova Scotia. They contain mainly plant-derived material, and probably produced the gas found in the large Venture field. Off Newfoundland, another shale in the Rankin Formation is probably the source rock for the Hibernia oil field. It is believed to contain marine organic material.

As part of the Project, researchers will be examining these source rocks in detail. They know that the rocks were deposited as loose sediments in the ocean more than 140nbsp;million years ago. They also know, from studies of our present-day oceans, that sediment rich in organic matter is deposited and preserved in certain environments. Examples are deltas, estuaries and other marine environments where the currents transport organic matter. Knowing this, geologists can compare various characteristics of the rocks-such as the type of bedding, structures and the fossils found within them - to the sediment deposited in present-day environments. From this comparison they can then infer the conditions in which the source rocks were initially deposited and, importantly, predict the probability of source rock occurring elsewhere.

Back to Top

Do the oil and gas come from these source rocks?

Not directly. In fact, oil and gas are not usually recovered from the source rocks except in land areas where the rock can be excavated directly. Source rocks are usually fine-grained shales with very low permeability - the measure of how easily fluids, such as oil, can pass through them. Because of their low permeability, it would be difficult - if not impossible - to pump oil out of shales from an offshore well.

Fortunately, given sufficient time and pressure, the source rocks give up the oil and gas naturally. The pressure of the overlying sediment squeezes them out of the shale, and they migrate upwards through the rock following a complex path of minute cracks and pore spaces.

In the Hydrocarbon Charge Modelling project, researchers hope to develop a set of equations that will define the timing of the generation and movement of oil and gas within the source rock (primary migration), and their expulsion into, and flow through the reservoir rock (secondary migration). For each sedimentary basin studied, the calculations will have to take into account several factors: the physical and chemical properties of the rock that have been measured in numerous wells drilled in the region over the last 20 years; and the subsidence, temperature and pressure histories of the basins. If successful, the result should be a complete, integrated picture of the migration of hydrocarbons through the basin.

Back to Top

Where do the oil and gas end up?

Most oil and gas off Eastern Canada is recovered from porous rocks, such as sandstones. They have numerous tiny holes or cracks through which the oil and gas can migrate and in which they can be stored. Because of this high permeability, the oil and gas can be extracted easily. Such rocks are called reservoirs and may contain oil, gas and water in varying quantities.

In order for the oil and gas to remain in the reservoir and not migrate on through the overlying rock, the reservoir must have a seal of low permeability rock around it. The seal may be formed simply by a layer of shale or by the folding and faulting of rock layers around the reservoir. These are called traps. A variety of styles of trap can form productive reservoirs. Many of them off both Nova Scotia and Newfoundland are structural traps, related to faulting and folding in the sedimentary basin.

As in many things, timing is crucial for an accurate prediction of the likelihood of oil or gas being present in a reservoir, it is extremely important to understand the timing of migration in relation to the timing of trap formation. Changing of reservoirs before the trap has formed may lead to dry exploration wells.

Back to Top

Why is hydrocarbon charge modelling

important for Canadians?

Because it is important that Canada manage its oil and gas resources effectively. As can be seen, the formation of a commercial oil or gas field depends on a wide range of factors coming together in the right combination, there must be a suitable source rock and a good reservoir rock; the oil and gas must migrate to the reservoir and be trapped there by either a shale seal or a structural trap. All these processes take place more or less independently.

The aim of the Hydrocarbon Charge Modelling project is to describe these processes quantitatively - to put number to the properties and processes that control hydrocarbon preservation. Petroleum geologists can then use the information to predict likely sites for hydrocarbons both within the two basins being studied and in other basins in Canada and around the world.

The GSC collaborates with researchers from universities and the petroleum industry so that both sectors will gain from the knowledge directly. And policy makers in the federal and provincial governments will benefit from the increased understanding of petroleum resources and their contribution to Canada's wealth.

Back to Top

Information

For further information on minerals, mining and geological research in Nova Scotia, please contact:

Nova Scotia Department of Natural Resources Library
Third Floor, Founders Square
1701 Hollis Street, P. O. Box 698
Halifax, Nova Scotia
B3J 2T9

Telephone: 902-424-8633
FAX: 902-424-7735
E-mail: nsdnrlib@gov.ns.ca

Back to Top

Photos: (Not presently available)

The Bow Drill I drilling on the Scotian Shelf, one of Canada's largest sedimentary basins.

Rowan Gorilla III drilling the first production well at the Panuke field, off the coast of Nova Scotia

Back to Top

Figures: (Not presently available)

Subsidence history of the sediments of the Term Nova K-08 oil well offshore Newfoundland. Source rock sediments were deposited around 150 million years ago. The

solid line shows the predicted subsidence of this rock body over time. 138 million years ago it was at 1500 m, 76 million years ago, at 3500 m. In the present day, it is at 3750 m depth. As the rock subsides it is compacted, heated and eventually releases oil. Salt Production in Nova Scotia.

A cross-section of a sedimentary basin, including typical temperature depth profiles. Hydrocarbons generated at B migrate until trapped by barriers to flow (at A).

Cross section of an oil trap. A seal of low permeability rock (shale for example), prevents oil from migrating out of the reservoir.

Back to Top

Mineral Resources Branch Home Page Natural Resources Home Page

GOV'T INDEX

The contents of this site are best viewed with an enhanced browser such as Microsoft® Internet Explorer® or Netscape® Navigator®.

Comments and questions about this web site.
This page and all contents are copyright 2001-2005
Mineral Resources Branch,
Department of Natural Resources,
Province of Nova Scotia,
all rights reserved.
Page last updated June 3, 2005.

Privacy Policy: http://gov.ns.ca/govt/privacy/privacypolicy.HTM